Benthic Fauna of an Offshore Borrow Area in Broward County, Florida

by

David B. Turbeville and G. Alex Marsh

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Benthic fauna from two stations within a 5-year-old borrow area and two control stations off Hillsboro Beach (Broward County), Florida, were sampled quarterly from June 1977 to March 1978 to evaluate the long-term impact of offshore dredging. Generally enhanced productivities occurred within the borrow area, although there was much seasonal variation among stations. Species diversities were usually higher at the borrow stations than at the control stations. The single exception was due to a high concentration of the bivalve

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E. nitens at one of the control stations in June. Although faunal similarity analysis revealed a qualitative change in the fauna of the borrow area, this change is not considered detrimental. Conspicuous patterns of heterogeneous faunal distributions were evident in this study, particularly for the bivalve *E. nitens*. No lasting detrimental effects, in terms of numbers of species, faunal densities, or species diversity, resulted from the dredging operation.

PREFACE

This report provides coastal engineers an evaluation of the long-term impact of offshore dredging on benthic fauna at Hillsboro Beach (Broward County), Florida. The report is published under the coastal ecology research program of the U.S. Army Coastal Engineering Research Center (CERC).

The report was prepared by David B. Turbeville, Director of the South Florida Institute of Marine Science at Fort Lauderdale, Florida, and Dr. G. Alex Marsh, Professor of Ecology at Florida Atlantic University, supported by grants from the Florida Sea Grant Program and the Joint FAU-FIU Center for Environmental and Urban Problems. The authors acknowledge D.R. Deis and H.D. Rudolph, Florida Department of Natural Resources, for their assistance in the identification of polychaetes, and P. Mikkelson for identifying many of the molluskan species. M. Clark and D. Conner provided invaluable assistance with computer programing.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

BENTHIC FAUNA OF AN OFFSHORE BORROW AREA IN BROWARD COUNTY, FLORIDA

by
David B. Turbeville and G. Alex Marsh

I. INTRODUCTION

Beach erosion is a serious problem nationwide, with approximately 43 percent of America's shoreline, excluding Alaska, undergoing significant loss (Callahan, 1980). In southeastern Florida, more than half of the 166.8 kilometers of recreational beach in Palm Beach, Broward, and Dade Counties is listed by the Florida Department of Natural Resources as being in a "critical state of erosion" (Marsh, 1980). This problem has necessitated periodic beach restoration and maintenance projects, generally involving the dredging of sand from offshore deposits called borrow areas. Sand from a borrow area is pumped through pipes onto the beach and bulldozed in place. Although many feel that the millions of dollars spent each year in southern Florida to restore degraded beaches are not cost effective since the sand will be lost eventually, others feel that the economic benefits through increased tourism and protection from storm and hurricane surge justify the expense.

Numerous studies have been conducted on the environmental effects of dredging and filling, although most of the research has centered on bays and estuaries. In Florida, the Tampa and Boca Ciega Bay areas have been studied extensively for the effects of oystershell dredging, canalization, and landfilling (Taylor and Saloman, 1968; Taylor, Hall, and Saloman, 1970; Saloman, 1974; U.S. Army Engineer District, Jacksonville, 1974; Simon and Doyle, 1974a, 1974b; Simon, Doyle and Conner, 1976; Conner and Simon, 1979).

Relatively little research has been conducted on the environmental impact of offshore dredging for beach restoration. Cronin, Gunter, and Hopkins (1971) reviewed potential effects of various engineering activities, including dredging, on coastal ecosystems, but included no quantitative data in their report. They felt that, "In many, perhaps most, coastal areas, the sand removed from the nourishment zone will be replaced by littoral drift, and the biological population will probably recover in a relatively short period of time." They also felt that the effects of borrowing and redistributing sediment would be greater in bays and estuaries than in the open ocean. In contrast, Dr. Robert Dolan, a University of Virginia authority of barrier beaches, stated that "the assumption that pits cause no permanent environmental disruption is questionable" (Callahan, 1980). Dolan also felt that beach biota, such as the mole crab, *Emerita* , would be largely destroyed by beach replenishment.

Only a few studies on the effects of offshore dredging for beach restoration have been conducted in Florida. Studies of the west coast include Holland, Chambers, and Blackman (1973), who reported that the creation of a borrow area off Lido Key resulted in at least a temporary increase in fishes along the beach and near the borrow area; and Saloman (1974), whose study of a 3-year-old offshore borrow area near Treasure Island revealed a decrease in the diversity and abundance of benthic invertebrates within the pit compared to the adjacent, relatively undisturbed bottom. However, a recent report by Saloman, Naughton, and Taylor (1981) on the effects of beach nourishment on benthic fauna at Panama City, Florida, concluded that postnourishment recovery in the borrow pit was virtually complete after 1 year. On the east coast of Florida a study of a borrow area located off Duval County also showed complete recovery of the fauna within 1 year of dredging (Applied Biology, Inc., 1979). Courtenay, et al. (1974) surveyed the fishes and nearshore reef communities following beach restoration in Broward County. Although no adverse effects were observed from Pompano Beach to Lauderdale-by-the-Sea, substantial physical damage to the reefs, probably due to careless handling of dredging equipment, occurred at Hallandale. Courtenay, Hartig, and Loisel (1980) resurveyed the area described in the 1974 report, primarily with reference to fish populations. They reported the disappearance of the dusky jawfish, *Opistognathus whitehursti* , and attributed it to the incursion of beach-fill materials on the first reef, which reduced the bottom relief and grain size of the substrate. Marsh, et al. (1980) studied the benthic communities and nearby reefs adjacent to the same beach and found no apparent deleterious effects of the 1971 restoration project.

Since beach restoration is expected to increase in the future, more information is needed on the long-term environmental effects of such operations. This study provides an evaluation of benthic communities within a borrow area created off Hillsboro Beach (Broward County), Florida, in 1972. These communities were sampled quarterly for 1 year (1977-78) and compared with communities from nearby, comparatively undisturbed areas.

II. STUDY AREA

The inshore topography off northern Broward County consists of two or three sandy flats interrupted by linear outcrops (reefs) of Pleistocene limestone (Fig. 1). These linear outcrops, or reefs, support a wide variety of invertebrates and fishes.

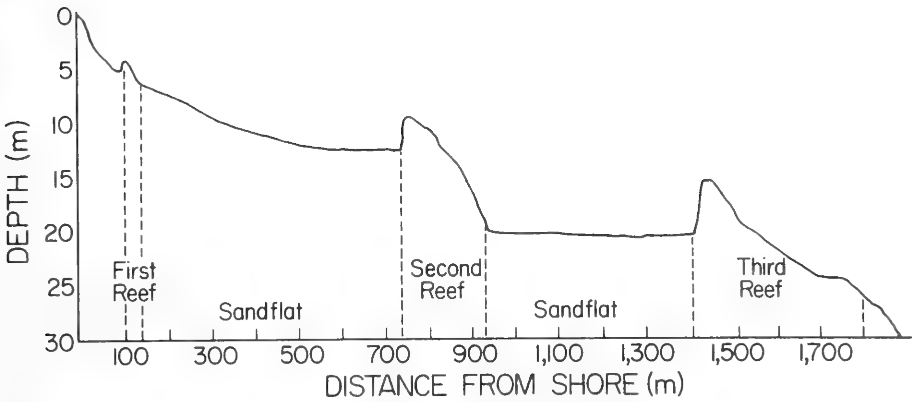

Figure 1. Profile of shelf morphology off Hillsboro Beach, Florida.

The study site, located approximately 1.6 kilometers south of the Deerfield Beach fishing pier (Fig. 2), has three such reef lines. The first is a low profile reef, 30 to 40 meters wide in a water depth of 5 to 6 meters. The inshore edge of the reef is approximately 100 meters from shore. Shoreward of the edge is a sand area with a series of scattered limestone outcrops and wormrock colonies of *Phragmatopoma lapidosa*.

The inshore edge of the second reef, which is 180 to 190 meters wide, is approximately 740 meters from shore at a depth of 10.5 to 12.5 meters. The outer edge of this outcrop drops to a depth of approximately 20 meters.

Between the second and the third reefs is a relatively flat sand area approximately 500 meters wide. The third reef, located at a depth of 15 to 26 meters forms the seaward edge of the Continental Shelf (Duane and Meisburger, 1969). Beyond the third reef, the sandy bottom slopes relatively steeply to the floor of the Florida Straits.

Duane and Meisburger (1969) described the sediments within the sandflats as white to gray calcareous skeletal sands and gravel. These sediments are believed to have been produced in situ, and include fragments from marine algae, mollusks, foraminiferans, bryozoans, and corals. Also present are small amounts of echinoid spines, sponge spicules, alcyonarian sclerites, and worm tubes. The dominant nonskeletal materials include rod-shaped and elliptical pellets (probably fecal), semiconsolidated calcarenite oolites, and agglutinated worm tubes.

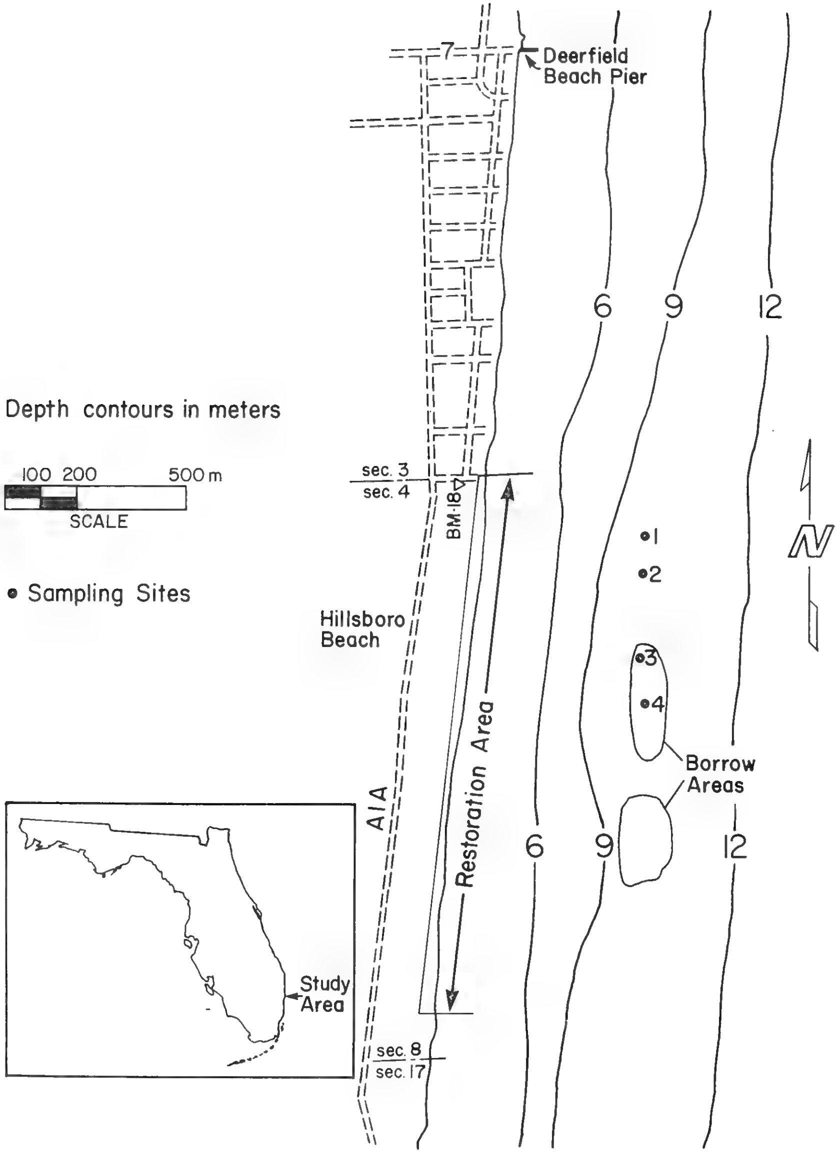

Figure 2. Location of study area and stations sampled.

The offshore borrow area is located between the first and second reefs (Figs. 1 and 2). During August and September 1972, approximately 274,016 cubic meters of sand was dredged and pumped from this area onto Hillsboro Beach, leaving two elongated pits in the ocean floor (Fig. 2). The northernmost pit is the sampling area evaluated in this study.

The borrow area, still well-defined 8 years after its excavation, is approximately 200 meters long and 70 to 75 meters wide. The inshore edge slopes from a depth of 10.0 meters outside the pit to a depth ranging from 13.5 to 15.0 meters inside. The outer edge of the trough is steeper than the shoreward edge, sloping up at a 30° to 40° angle to the undisturbed sea floor. Along the edge of the slopes is an area of rubble, left from the dredging operation, that is inhabited by many reef fishes and invertebrates. The sandy bottom of the borrow area is generally flat, except for a few scattered sunken tires broken away from a nearby artificial reef.

Water currents in this area are predominantly southerly, although there is considerable variability in both direction and velocity.

III. SAMPLING AND ANALYTICAL PROCEDURES

1. Sediment Analysis.

During the initial sampling period, three replicate core samples from each station were obtained for sediment analysis. An aliquot of each was dispersed for 24 hours in a 4-percent solution of sodium hexametaphosphate (Calgon), and then washed through a 0.063-millimeter sieve to separate the silts and clays from the sand. The sand was ovendried at 90° Celsius for 12 hours, then fractionated according to the Wentworth scale. Each fraction was weighed to the nearest 0.01 gram. Organic content was determined by ovendrying an additional sediment aliquot, then measuring the percent weight loss after incineration at 500° Celsius for 1 hour.

Significance testing of grain-size differences was conducted using an analysis of variance.

2. Faunal Analysis.

Seasonal samples of benthic fauna were collected from four sampling stations--two control stations (1 and 2), representing the comparatively undisturbed bottom and two borrow stations (3 and 4). Control stations 1 and 2 were located 300 and 200 meters, respectively, north of the borrow area (Fig. 2). Borrow stations 3 and 4 were located 90 meters apart within the borrow area.

Samples were collected on 16 June (summer), 21 September (autumn), and 16 December (winter) 1977, and on 26 March (spring) 1978. Samples were obtained by scuba divers using a hand-driven polyvinyl chloride (PVC) coring tube with an inside diameter of 7.9 centimeters (Fig. 3).

Figure 3. Core sampling of benthic fauna.

Twenty-four core samples containing the top 11 centimeters of sediment were collected at each station, giving a total area sampled at each station of 0.118 square meter. The adequacy of the sample size was indicated by plotting a cumulative species curve for cores from one control and one borrow station during the initial sampling period (Fig. 4). The curves tend to level off after about 21 cores, indicating that most of the common species were sampled.

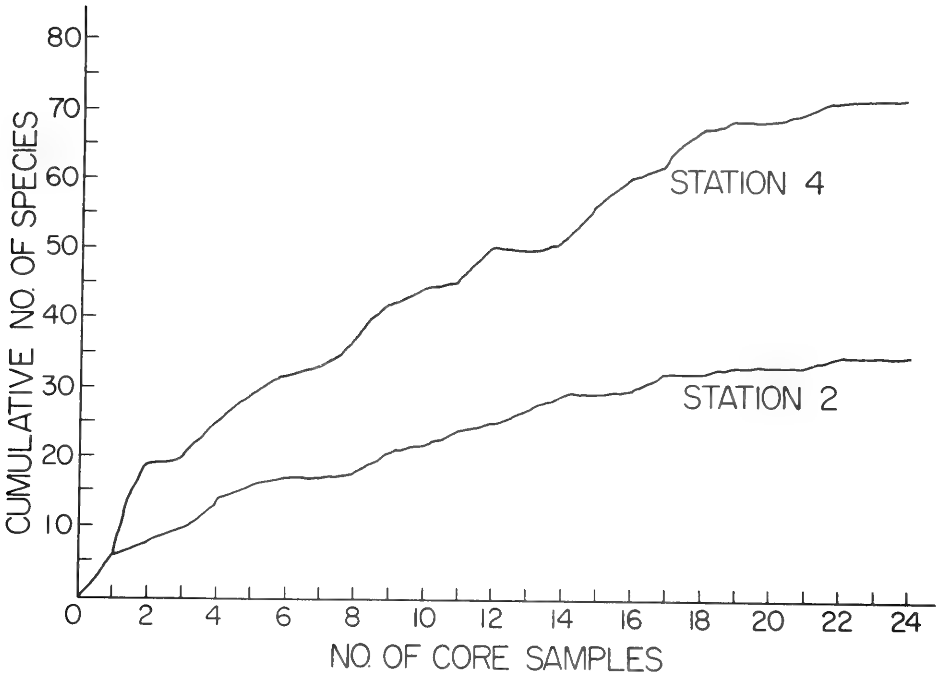

Figure 4. Cumulative number of species collected versus increased number of samples for stations 2 and 4.

Core samples were emptied individually into 3.8-liter Ziploc plastic storage bags, sealed underwater, and then brought to the surface. In the laboratory, samples were emptied into 3.8-liter jugs containing 10 percent seawater formalin stained with rose bengal. Core samples were later washed through a 1-millimeter sieve, and the organisms retained were preserved in 70 percent ethanol. All animals were identified to the lowest taxon possible. Voucher specimens of all species collected were deposited in the zoological museum at Florida Atlantic University, Boca Raton, Florida.

Significant differences in numbers of species and individuals between stations for each sampling period were tested according to the methods in Sokal and Rolf (1969a) and compared to the statistical tables in Sokal and Rolf (1969b). An F-max test was run on the raw data, which was found to be heterogeneous and required a square-root transformation; a two-way analysis of variance (ANOVA) with replication was performed on the transformed data. A priori (F-test) and a posteriori (Student-Newman-Keuls) significance tests were then run.

Species diversity was calculated by the Shannon-Weaver index, H', with the aid of a Univac 1106 computer:

$$H' = -\sum_{i=1}^{s} P_i \log P_i$$

where the probability that one individual belongs to species 1 is P_i, and P_i is n_i/N, where n_i is the number of individuals of the i^{th} species, and N the total number of individuals in the sample.

The equitability component of diversity (Pielou, 1966) was calculated as follows:

$$e = H'/\log S$$

where S is the total number of species.

Faunal similarity among samples was tested using Czekanowski's coefficient weighted for abundance. The computer program for this analysis is described in Bloom, Santos, and Field (1977). This coefficient is calculated as follows:

$$C_z = 2W/(A+B)$$

where A is the sum of the measures of all species in one sample, B the similar sum for the second sample, and W the sum of the lesser measures of each species for the two samples being compared (Field and McFarlane, 1968).

A matrix of coefficients was obtained, group average sorting was performed (as recommended by Field and McFarlane, 1968), and a dendogram was prepared.

IV. RESULTS

1. Sediments.

The dominant sediment sizes at all stations were fine to coarse sands (0.125 to 1.000 millimeter in diameter). Mean grain sizes were in the medium sand category (0.25 to 0.5 millimeter in diameter), and ranged from a low of 0.25 millimeter at station 2 to a high of 0.33 millimeter at station 4 (Table 1). Both borrow stations had slightly larger mean grain sizes than the control stations.

Table 1. Percent particle-size distribution, percent organic content, and mean grain size of sediments at stations 1, 2, 3, and 4.

	Particle-size distribution								
Station	Granules (2-4mm)	Very coarse sand 1-2mm)	Coarse sand (0.5mm)	Medium sand (0.25-0.5mm)	Fine sand (0.125-0.25mm)	Very fine sand (0.063-0.125mm)	Silts and clays (< 0.063)	Pct. organic content	Mean grain size (mm)
1	0.1	0.8	9.6	42.3	43.8	0.8	2.8	1.0	0.25
2	0.2	1.4	9.6	41.3	37.9	0.8	8.8	1.0	0.25
3	0.3	2.4	16.5	48.9	24.1	0.9	6.9	1.2	0.30
4	0.4	2.7	18.7	49.2	24.8	0.9	2.6	1.6	0.33

The sediment fractions in the very coarse sand (1 to 2 millimeters in diameter) category were significantly greater at the borrow stations than at the control stations (ANOVA, $p < 0.01$). This is evident in the histograms (Fig. 5) and cumulative frequency curves (Fig. 6).

The organic content of the sediments was low, ranging from 1.0 to 1.6 percent (replicate means at each station), and showed no significant differences among stations (Table 1).

2. Fauna.

Sampling of benthic fauna at the four stations through the year yielded a total of 5,933 individuals comprising 224 species (Apps. A and B). The dominant taxa were polychaete annelids (86 species and 32.4 percent of the individuals) and bivalve mollusks (33 species and 46.3 percent of the individuals).

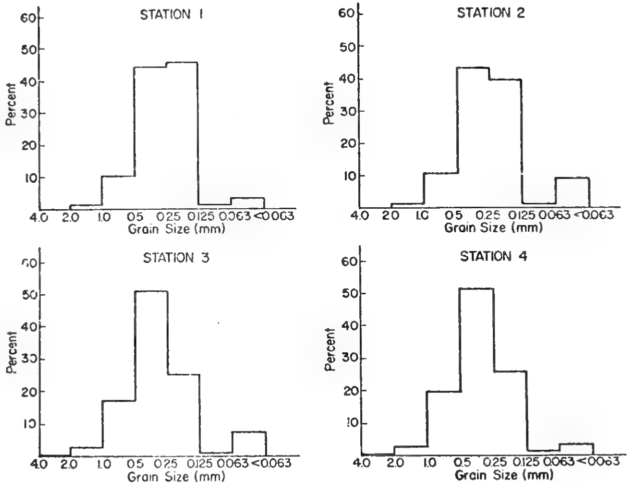

Figure 5. Distribution of substrate grain sizes at control stations 1 and 2 and borrow stations 3 and 4.

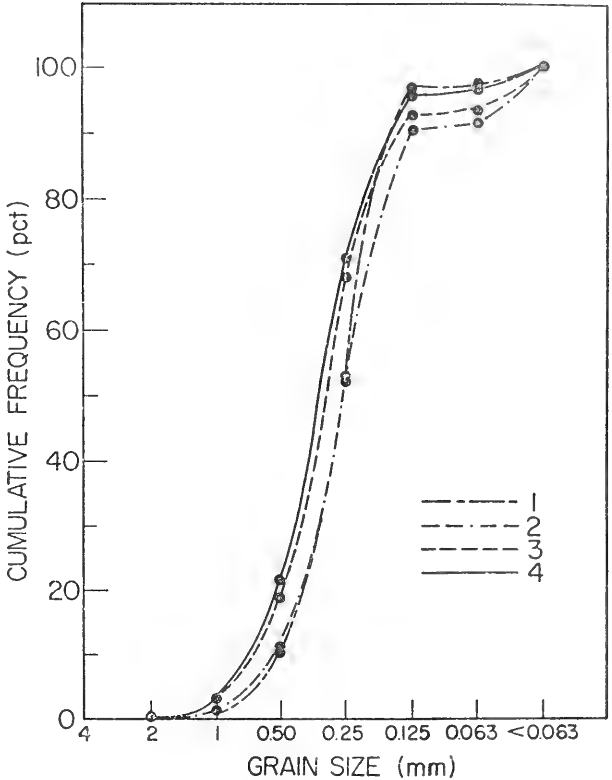

Figure 6. Cumulative percent of grain sizes at control stations 1 and 2 and borrow stations 3 and 4.

Six species comprised more than half (52.0 percent) of all individuals collected (App. A). These included four species of bivalve mollusks (*Ervilia nitens, E. concentrica, Transennella stimpsoni,* and *Pleuromeris tridentata*), one polychaete (*Lumbrinereis tenuis*), and one tanaidacean (*Apseudes* sp.). More than half (54.0 percent) of the species collected were represented by five or fewer individuals.

The numbers of species and individuals collected at each station during the four sampling periods are shown in Table 2. Borrow station 3 yielded the largest number of species and individuals in all sampling periods except June, when borrow station 4 had more individuals. However, 60.4 percent of the fauna at borrow station 4 in June were represented by only one species, the bivalve *E. nitens*. Although this species attains adult size at 7 to 10 millimeters (Abbott, 1974), only juveniles (2 to 3 millimeters) were collected in the present study. *E. nitens* accounted for 23.6 percent of all individuals collected in the study (App. A).

Table 2. Total number of species, individuals, and extrapolated faunal densities.

Sampling date	Station	No. of species	No. of individuals	Extrapolated faunal densities[1]	
June 1977	1	44	216	1,831	
	2	38	187	1,585	
	3	80	539	4,568	
	4	65	1,514	12,831	
		Total number of different species:			133
		Total number of individuals:			2,456
September 1977	1	63	404	3,424	
	2	42	126	1,068	
	3	86	631	5,347	
	4	60	236	2,000	
		Total number of different species:			133
		Total number of individuals:			1,397
December 1977	1	30	322	2,729	
	2	26	305	2,585	
	3	98	517	4,381	
	4	58	204	1,729	
		Total number of different species:			125
		Total number of individuals:			1,348
March 1978	1	39	103	873	
	2	41	151	1,280	
	3	67	283	2,398	
	4	66	195	1,653	
		Total number of different species:			108
		Total number of individuals:			732

[1]Measured by individuals per square meter.

As shown in Table 2, extrapolated faunal densities ranged from 873 individuals per square meter (control station 1 in March) to 12,831 individuals per square meter (borrow station 4 in June). The average densities for each sampling date in individuals per square meter showed a steady decline through the sampling period--5,204 in June; 2,960 in September; 2,856 in December; and 1,551 in March.

In June, control stations 1 and 2 showed no significant differences in the numbers of species or individuals. These stations were also very similar in their species compositions, as indicated in Figure 7, which shows groupings of stations based on degrees of faunal similarity. The relationship between borrow stations was quite different. Borrow station 3 had a significantly greater number of species than borrow station 4, but the latter contained over twice as many individuals. These differences, caused in part by the high concentration of *E. nitens* at borrow station 4, were also largely responsible for the borrow stations having a relatively low degree of faunal similarity at this time (Fig. 7). The combined borrow stations had significantly more species and individuals than the combined control stations ($p < 0.001$).

In September, control station 1 contained significantly greater numbers of both species and individuals than control station 2 ($p < 0.001$). As expected, these stations also showed little faunal similarity (Fig.7). Borrow station 3 yielded siginificantly more species and individuals than borrow station 4 ($p < 0.001$). These stations also showed relatively little faunal similarity (Fig. 7). The two borrow stations combined contained significantly greater numbers of species and individuals than the two control stations combined ($p < 0.001$).

In December, control stations 1 and 2 showed no significant differences with respect to numbers of species or individuals, and also showed a high degree of faunal similarity (Fig. 7). Both stations (1 and 2) contained large numbers of *E. nitens* (223 and 194, respectively). Borrow station 3 contained more than twice as many individuals and almost twice as many species as borrow station 4. Although their level of faunal similarity was not particularly high, these stations did occur together in one of the four major groupings in the similarity dendogram (Fig. 7). The low number of individuals collected at borrow station 4 resulted in no significant differences between the two control stations combined and the two borrow stations combined in terms of faunal densities. However, there were significantly more species at the borrow stations combined than at the control stations combined ($p < 0.001$).

In March, the control stations showed no significant differences in numbers of species or individuals, and also showed a close association in the similarity dendogram (Fig. 7). This was also true for the borrow stations on this sampling date.

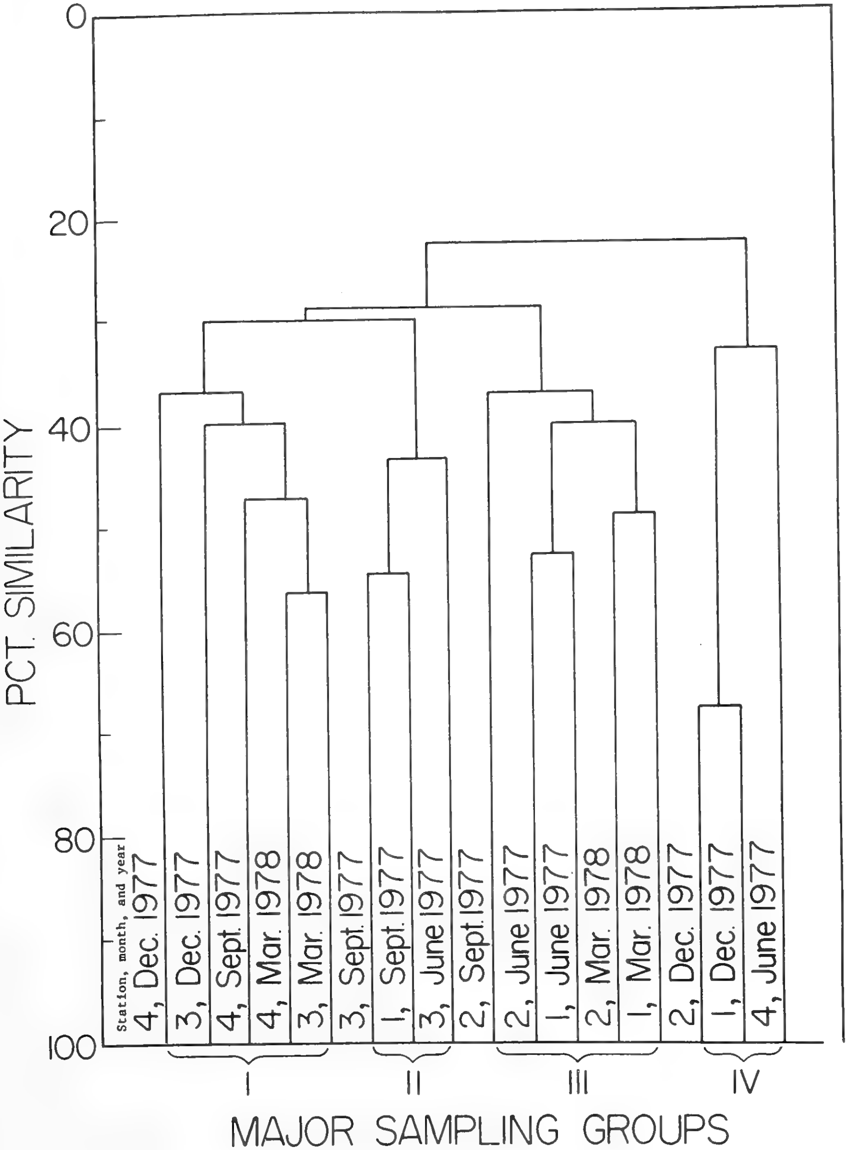

Figure 7. Faunal similarity dendogram, grouped according to degree of similarity.

Four major station groupings are evident in Figure 7. Group I is composed entirely of borrow stations (3 and 4 in December and March, and 4 in September). Group II is composed of borrow station 3 in June and September, along with control station 1 in September. The control station had several numerically important species in common with one or the other of the borrow stations in this group, including the bivalves *E. concentrica*, *T. stimpsoni*, and *P. tridentata*, and the polychaetes *L. tenuis* and *Axiothella mucosa*. Another reason for the association of the control station with the borrow stations in this group is the relatively large number of both species and individuals that it contained in this sampling period. As discussed previously, this was the only time that the two control stations themselves differed significantly in numbers of species or faunal abundance. Group III is composed entirely of control stations (stations 1 and 2 in June and March, as well as station 2 in September). Group IV is composed of control stations 1 and 2 in December and borrow station 4 in June. This association is largely explained by the great numbers of *E. nitens*. occurring at all these stations on these dates.

The associations indicated in the dendogram are due mainly to similarities among groups of either control or borrow stations. This suggests that the borrow station populations are different from the control station populations. The relatively few cases in which borrow stations were grouped with control stations usually could be attributed to the common occurrence of one or two abundant species.

Species diversity (H') and equitability (e) values for each station are shown in Table 3. On all sampling dates except June, the diversity values for the borrow stations were slightly higher than those for the controls. At borrow station 4 in June, large concentrations of the bivalves *E. nitens* and *E. concentrica* resulted in both low equitability and H' values.

Table 3. Shannon-Weaver species diversity (H') and Equitability (e) values for each station by sampling date.

		Sampling Date			
Station	Index	June 1977	Sept. 1977	Dec. 1977	Mar. 1978
1	H'	4.4462	4.4483	2.1148	4.3555
	e	2.7150	2.4722	1.4317	2.7374
2	H'	4.1610	4.6269	2.2006	4.4412
	e	2.6339	2.8505	1.5552	2.7537
3	H'	4.7772	4.6399	5.1802	4.9993
	e	2.5102	2.3985	2.6015	2.7377
4	H'	2.2408	5.0037	4.8084	5.2989
	e	1.2360	2.8139	2.7268	2.9123

Declines in diversity were evident at control stations 1 and 2 during the winter, when values dropped to less than half their values at all other sampling dates. This, again, resulted in part from large concentrations of *E. nitens* at these stations, as well as from seasonal fluctuations in the abundance of other species.

V. DISCUSSION

Studies of benthic communities have contributed much to our understanding of the role of stress and disturbance in the marine environment (Boesch and Rosenberg, in preparation, 1982). Because most benthic organisms are sedentary and relatively long-lived, their response to man-induced stresses, such as offshore dredging, can readily be analyzed statistically, yielding much information for use in coastal resource management.

Our analysis of benthic fauna within the borrow areas showed no lasting detrimental effects on numbers of species, faunal densities, or species diveristy from dredging that occurred 5 years previously. In fact, data combined from borrow stations showed significantly greater numbers of species and individuals than that from control stations. Species diversity values were also unusually higher at the borrow stations.

Our findings are generally in accord with those of two other recent studies of offshore dredging in Florida, both designed to assess short-term ecological effects. Saloman, Naughton, and Taylor (in preparation, 1982) found that the fauna within a borrow pit off Panama City (Bay County) showed rapid postnourishment recovery that was nearly complete after 1 year. Similarly, in an unpublished study of a borrow area located 11.1 kilometers off Duval County in northeastern Florida, no significant differences were found 1 year after dredging between borrow and control stations in numbers of taxa, faunal densities, or species diversities (Applied Biology, Inc., 1979).

These observations are different from those reported by Saloman (1974) in his study of a borrow area created 3 years previously off Treasure Island (Pinellas County) on the west coast of Florida. He found low densities and diversities of benthic fauna within the borrow area compared to surrounding, relatively undisturbed bottom. He attributed these differences to thick deposits (> 3 meters) of gelatinous, organic-rich sediments that had accumulated in the borrow area, resulting in low dissolved oxygen concentrations. These conditions did not develop off Hillsboro Beach, probably because of the low concentration of suspended particulates and the relatively strong longshore currents and eddies (Marsh, et al., 1978).

Reasons for the quantitative and qualitative differences between borrow and control stations are difficult to ascertain. Sediment composition, including grain size, is an important determinant of community composition, (Wilson, 1952; McNulty, Work, and Moore, 1962; Thorson, 1966; Sanders, 1968; Bloom, Simon, and Hunter, 1972; Gray, 1974). Jansson (1967) described grain-size distribution as the major environmental parameter influencing the distribution of infaunal animals. The fact that sediments within the borrow area were significantly coarser than at the control stations may explain the faunal differences observed. Following its excavation, the borrow pit became, in effect, a new benthic habitat open to colonization by Planktonic larvae, many of which are known to be highly selective for various sediment parameters, including grain size.

Faunal densities recorded in this study were generally lower than those reported by Marsh, et al.(1980) for offshore areas at Hallandale and Golden Beach, Florida, approximately 35 kilometers to the south. Their study included samples from stations between the first and second reefs, as in the present study, although their sampling area was shallower (6 meters compared to 10 to 15 meters off Hillsboro Beach). Moreover, sediments off Golden Beach and Hallandale were coarser than at Hillsboro Beach. Marsh, et al. (1980), using a similar screen size, reported faunal densities ranging from 11,305 to 17,144 individuals per square meter during November-December 1977. Oligochaetes accounted for 38.3 percent of the fauna collected. In our study, faunal densities ranged from 1,729 to 4,381 individuals per square meter, in December with oligochaetes accounting for only 1.4 percent of the fauna. Thus, considerable faunal heterogeneity can occur within a short length of coastline.

It is concluded that the offshore dredging operations conducted in 1972 off Hillsboro Beach, Florida, caused no long-term observable adverse effects, in terms of reduced numbers of species, reduced faunal abundance, or reduced species diversity within the borrow area. Qualitative changes in the borrow area, as indicated by cluster analysis, were not considered detrimental.

VI. SUMMARY

The long-term ecological effects of dredging for beach restoration were investigated off Hillsboro Beach (Broward County), Florida. Benthic fauna were collected quarterly for 1 year, by scuba divers using a hand-driven PVC coring tube, from four offshore stations. Control stations 1 and 2 represented relatively undisturbed bottom; borrow stations 3 and 4 were within an area excavated 5 years previously.

At each station during the initial sampling date, three replicate sediment samples were collected for analysis. Borrow stations 3 and 4 had significantly coarser sediments than control stations 1 and 2. There was no significant difference in organic content among stations.

A total of 5, 933 individuals comprising 224 species were collected. The dominant taxa were polychaete annelids and bivalve mollusks. Generally enhanced productivities were evident at the borrow stations throughout the year, with borrow station 3 consistently containing more species and individuals than the control stations. Species diversities were usually higher at the borrow stations than at the control stations, with the single exception due to a high concentration of the bivalve *E. nitens* at borrow station 4 in June.

Although the faunal similarity analysis indicated that a qualitative change in the fauna of the borrow area had occurred, this change was not considered detrimental. Conspicuous patterns of heterogeneous distribution of fauna were evident in this study, particularly with the bivalve *E. nitens*. Pronounced seasonal fluctuations in species composition and abundance were noted at each station.

It is concluded that the offshore dredging operations conducted in 1972 off Hillsboro Beach, Florida, caused no observable adverse effects, in terms of reduced numbers of species, reduced faunal abundance, or reduced species diversity within the borrow area.

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APPENDIX A

SPECIES LIST AND NUMBER OF INDIVIDUALS SAMPLED BY STATION AND SAMPLING PERIOD

Species	June 1977				Sept. 1977				Dec. 1977				Mar. 1978				Total	Pct. Total	Cumulative Pct.
Stations:	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4			
Ervilia nitens	8			915			43		223	194	2	15			2		.1402	23.63	23.63
Ervilia concentrica	14	3	78	281	37	3	71	1			1		2	2			493	8.31	31.94
Transennella stimpsoni	29	27	93	90	41	1	76	6	11	9	8	1	16	16	1	1	426	7.18	39.12
Lumbrinereis tenuis	14	16	19	5	42	20	35	30	14	27	52	20	4	11	19	16	344	5.80	44.92
Pleuromeris tridentata	2	5	10	16	80		79	9		1	4	3			10	1	220	3.71	48.63
Apseudes sp.	4		12	8	5		8	18	2	1	58	23			48	12	199	3.35	51.98
Aspidosiphon albus		1	27	36	3		6	4	1		35	19			15	12	159	2.68	54.66
Aricidea jeffreysi	14	9	12	6	6	9	14	11	4	3	3	9	6	9	9	3	127	2.14	56.80
Trichophoxus floridanus	29	24	2			7		1	6	23		1	9	10	3	2	117	1.97	58.27
Caecum imbricatum	4		35	15	5	3	25	8	1	1	1	4		4			106	1.79	60.56
Armandia agilis	13	27	4	8	1	4	2	3	7	1	1	1	4	7	4	2	89	1.50	62.06
Axiothella mucosa	2	6	14		28	3	6	7	2		10	1		1	3	2	85	1.43	63.49
Platyischnopus sp.	6	7			1	8	1		15	12	3	4	17	8	1	1	84	1.41	64.90
Prionospio fallax	1		28		7	8	16	7			7	2	2	1	3	1	83	1.40	66.30
Polydora socialis			5				65	4			1			1	1		77	1.30	67.60
Aricidea sp.			4		11	3	8	4	2	3	4	3	3	5	16	8	74	1.25	68.85
Neonotomastus glabrus	2	5	10	4	1	3	12	8	2	2	11	5	1		3	1	70	1.18	70.03
Lumbrinereis acuta	10	7	7	3					3	5	11	2	2	2	6	7	65	1.10	71.13
Oligochaeta sp. A			1								60	2					63	1.06	72.19

Species	Stations :	June 1977 1	2	3	4	Sept. 1977 1	2	3	4	Dec. 1977 1	2	3	4	Mar. 1978 1	2	3	4	Total	Pct. Total	Cumulative Pct.
Aedicira sp.									18	2			10	2	6	8	3	49	0.83	73.02
Drilonereis sp. A.		6	10	8			2			1	2	7		1		9	1	47	0.79	73.81
Aonides sp.			1	16		11				1		5	2			5	4	45	0.76	74.57
Syllis (*Langerhansia*) sp.				1	5			2	6			18	2		1		10	45	0.76	75.33
Kalliapseudes sp.									1			21	14				7	43	0.72	76.05
Drilonereis sp. C					4	1						13	1			14	9	42	0.71	76.76
Paraonis sp.		2					7		1	2	3		2	1	14	5	2	39	0.66	77.42
Phtisica marina		5	1	6	17			1			2						6	38	0.64	78.06
Tellina gouldii		1	2	1		2	4	1	1	7	1	1	6	4	2	1		34	0.57	78.63
Gammaridea sp. A		7		2	5	1	1	6	1					1	6			30	0.51	79.14
Chone sp.			1	5				2	4			4	2		1	6	4	29	0.49	79.63
Exogone dispar				12	3	4		5				3	1				1	29	0.49	80.12
Tellina versicolor		1		3	1	4		9	4	1		1	2				2	28	0.47	80.59
Drilonereis sp. B				4	6		2					4			4	7		27	0.46	81.05
Chaetozone sp.				6				1	8			6			1	4		26	0.44	81.49
Eusyllis sp. A		2		3		3		3	4			5		1	3	2		26	0.44	81.93
Nemertea sp. A		2		8	3	5		2				4	1					25	0.42	82.35
Branchiostoma caribaeum		3		3		2			1			9	1			2	3	24	0.40	82.75
Hesionidae sp.					1	5			3			6	1			4	4	24	0.40	83.15
Sigalion sp.		1		1			1	4	1		3	1	4	1	1	3	3	24	0.40	83.55

Species	Stations:	June 1977 1	2	3	4	Sept. 1977 1	2	3	4	Dec. 1977 1	2	3	4	Mar. 1978 1	2	3	4	Total	Pct. Total	Cumulative Pct.
Scoloplos rubra				2		4	2	5				3	2		4		1	23	0.39	83.94
Minuspio sp.												2	1	1	16	1	1	22	0.37	84.31
Prionospio cristata						3		2	6			3	4		1	1	1	21	0.35	84.66
Parahaustorius sp. A.		8	2			1				2	3				1	1		18	0.30	84.96
Glycera sp.			2	2	2	2	3	1				1			1	2	1	17	0.29	85.25
Onuphis eremita			1	5	6			1				2				2		17	0.29	85.54
Onuphis pallidula				10	4							1			2			17	0.29	85.83
Poecilochaetus sp.				1	5	1		7	3									17	0.29	86.12
Thalenessa sp.				2	1	2		3					1	3		4	1	17	0.29	86.41
Bathycuma longicaudata		1	1		1	4		3	2	1	1				1	2		17	0.29	86.70
Phyllodoce mucosa				2		1		3	3			1	1			3	2	16	0.27	86.97
Crassinella lunulata				2		10		1				1		1	1			16	0.27	87.24
Zebina browniana					1						1	5	1	1		6	1	16	0.27	87.51
Branchioasychis sp.		1				11			2								1	15	0.25	87.76
Onuphis sp.												11	1			1	2	15	0.25	88.01
Mysidacea sp. A		2	2			6	2	2						1				15	0.25	88.26
Oligochaeta sp. B												5	1			8	1	15	0.25	88.51
Schistomeringos rudolphi								2				2			1	3	6	14	0.24	88.75
juvenile bivalves							14											14	0.24	88.99
Processa sp.		7		4	2				1									14	0.24	89.23

Species	Stations: June 1977 1	2	3	4	Sept. 1977 1	2	3	4	Dec. 1977 1	2	3	4	Mar. 1978 1	2	3	4	Total	Pct. Total	Cumulative Pct.
Xenanthura brevitelson	3	2			2		1				3	3					14	0.24	89.47
Crenella sp.							7	6									13	0.22	89.69
Varicorbula operculata			2	1			4	4			1						12	0.20	89.89
Polynoidae sp. C			1		4		2		2				1		1		11	0.19	90.08
Capitellidae sp. B			1		4			1		3	1			1			11	0.19	90.27
Apoprionospio dayi			1	1		4	1	1	1				1	1			11	0.19	90.46
Malacoceros glutaeus	1			2	2	1	1					1	1	1	1	1	11	0.19	90.65
Polyschides quadridentatus											5	1			3	2	11	0.19	90.84
Euphrosine sp.			4		1		1								3	1	10	0.17	91.01
Magelona sp.			4	3			2	1									10	0.17	91.18
Astenothaerus hemphilli			2				6					2					10	0.17	91.35
Strigilla mirabilis	1			1	1	1			2				1	2	1		10	0.17	91.52
Americonuphis sp.	2		1	4						2							9	0.15	91.67
Loimia medusa			4		1		1			2						1	9	0.15	91.82
Venereidae sp.		3			1	1	1			3							9	0.15	91.97
Sigatica carolinensis	1		1	2	3					1	1						9	0.15	92.12
Nephtys picta				2	1		1	1	1						1	1	8	0.13	92.25
Nereidae sp. A								2		3					2	1	8	0.13	92.38
Commensodorum commensalis			3	1	1					1					2		8	0.13	92.51
Sabellidae sp. B			1		1	1	3			1					1		8	0.13	92.64

Species	Stations:	June 1977 1	2	3	4	Sept. 1977 1	2	3	4	Dec. 1977 1	2	3	4	Mar. 1978 1	2	3	4	Total	Pct. Total	Cumulative Pct.
Lima sp.					4								2			2		8	0.13	92.77
Coccodentalium carduum				2						1		1	1			3		8	0.13	92.90
Serolis mgrayi		1				2						1		1	3			8	0.13	93.03
Armandia maculata									3							4		7	0.12	93.15
Pholoe sp.		2	1		1			1	1					1				7	0.12	93.27
Prionospio sp.					7													7	0.12	93.39
Paraprionospio pinnata				3		2	1			1								7	0.12	93.51
Spio pettiboneae			3	1				1									2	7	0.12	93.63
Cadulus sp.			1		1	2	1	2										7	0.12	93.75
Polinices lacteus					1			1		1						3	1	7	0.12	93.87
Portunas depressifrons			1		1	1	4											7	0.12	93.99
Synchelidium americanum			1				2	3						1				7	0.12	94.11
Pseudocirratulus kingstonensis												4					2	6	0.10	94.21
Lumbrineridae sp. A							1					3				1	1	6	0.10	94.31
Minuspio cirrifera				1		1	1	2	1									6	0.10	94.41
Eusyllis sp. B								2				1	1		1	1		6	0.10	94.51
Lucina sp.								6										6	0.10	94.61
Pteromeris perplana				1								5						6	0.10	94.71
Cooperella atlantica				3				2							1			6	0.10	94.81

Species	Stations:	June 1977 1	2	3	4	Sept. 1977 1	2	3	4	Dec. 1977 1	2	3	4	Mar. 1977 1	2	3	4	Total	Pct. Total	Cumulative Pct.
Tivela floridana		1						2	3									6	0.10	94.91
Atys caribaea							3	1				2						6	0.10	95.01
Marginella eburneola			1		2			1								2		6	0.10	95.11
Mysidacea sp. B							2							2	1		1	6	0.10	95.21
Nemertea sp. B												2	4					6	0.10	95.31
Phyllodoce (*Gentyllis*) sp.							1	2				1					1	5	0.08	95.39
Syllis (*Typosyllis*) sp.												5						5	0.08	95.44
Exogone sp.												4			1			5	0.08	95.55
Chione latirata				1					4									5	0.08	95.63
Tellina sp. A											3					2		5	0.08	95.71
Natica canrena		1			2		1		1									5	0.08	95.79
Acteocina candei					2								3					5	0.08	95.87
Mitrella ocellata		3										1			1			5	0.08	95.95
Penaeidae sp.						2		1	2									5	0.08	96.03
Cyclapsis varians					1				1						1		2	5	0.08	96.11
Parahaustorius sp. B		1									1			3				5	0.08	96.19
Alpheidae sp.		5																5	0.08	96.27
Nemertea sp. E																1	4	5	0.08	96.35
Notomastus sp.												4						4	0.07	96.42

Species	Stations:	June 1977 1	2	3	4	Sept. 1977 1	2	3	4	Dec. 1977 1	2	3	4	Mar. 1978 1	2	3	4	Total	Pct. Total	Cumulative Pct.
Phyllodocidae sp. C												4						4	0.07	96.49
Syllidae sp.												1	1				2	4	0.07	96.56
Bivalvia sp. C							3	1										4	0.07	96.63
Olivella floralia						1						2			1			4	0.07	96.70
Tricolia thalassicola								3							1			4	0.07	96.77
Pisania tincta								2				2						4	0.07	96.84
Luconacia incerta		1		2	1													4	0.07	96.91
Serolis sp.						1		1								1	1	4	0.07	96.98
Thalassinoidea sp.				4														4	0.07	97.05
Gammarus sp.									1			3						4	0.07	97.12
Sipuncula sp. A			3													1		4	0.07	97.19
Capitellidae sp. A									1							1	1	3	0.05	97.24
Lumbrineridae sp. B															1		2	3	0.05	97.29
Nereidae sp.						1	1						1					3	0.05	97.34
Orbinia sp.						1	1	1										3	0.05	97.39
Sabellidae sp. A												3						3	0.05	97.44
Malacoceros sp. B					3													3	0.05	97.49
Polychaeta sp.									1			2						3	0.05	97.54
Lepidopleurus pergranatus				1					2									3	0.05	97.59

Species		June 1977				Sept. 1977				Dec. 1977				Mar. 1978				Total	Pct. Total	Cumulative Pct.
	Stations:	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4			
Dentalium semistriolatum					2	1												3	0.05	97.64
Marginella lavalleeana						2											1	3	0.05	97.69
Pinnixa retinens				3														3	0.05	97.74
Cycloes barrdii								1							1	1		3	0.05	97.79
Ampelisca sp.					1									1		1		3	0.05	97.84
Pallenopsis schmitti								3										3	0.05	97.89
Pycnogonida sp.				1				1				1						3	0.05	97.94
Ophiuroidea sp.			3															3	0.05	97.99
Gillellus greyae							1			1			1					3	0.05	98.04
Polycladida sp. B				1								2						3	0.05	98.09
Oligochaeta sp. C		1		1									1					3	0.05	98.14
Nemertea sp. C									1							1	1	3	0.05	98.19
Sipuncula sp. B		1			1			1										3	0.05	98.24
Dasybranchus sp.												1				1		2	0.03	98.27
Capitella sp.														1		1		2	0.03	98.30
Magelona pettiboneae								1			1							2	0.03	98.33
Phyllodocidae sp. A												2						2	0.03	98.36
Phyllodocidae sp. B												2						2	0.03	98.39
Malacoceros sp. A				2														2	0.03	98.42

Species	June 1977				Sept. 1977				Dec. 1977.				Mar. 1978				Total	Pct. Total	Cumulative Pct.
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4			
Dispio uncinata			2														2	0.03	98.45
Parapionosyllis ps.				1	1												2	0.03	98.48
Lucina radians		2															2	0.03	98.51
Crasinella sp.				2													2	0.03	98.54
Laevicardium laevigatum							1			1							2	0.03	98.57
Pandora bushiana											2						2	0.03	98.60
Odostomia sp.				1							1						2	0.03	98.63
Semele bellastriata											1	1					2	0.03	98.66
Dentalium floridense											1	1					2	0.03	98.69
Dentalium sp. A		1		1													2	0.03	98.72
Natica sp.				2													2	0.03	98.75
Mitrella raveneli							1				1						2	0.03	98.78
Majiidae sp. A		1		1													2	0.03	98.81
Batrachonotus fragosus							2										2	0.03	98.84
Cumacea sp. A				1				1									2	0.03	98.87
Ostracoda sp. B							2										2	0.03	98.90
Paracaprella pusilla															2		2	0.03	98.93
Caprellidae sp. A				2													2	0.03	98.96
Echiura sp.		2															2	0.03	98.99

Species		June 1977				Sept. 1977				Dec. 1977				Mar. 1977					Pct.	Cumulative
	Stations:	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	Total	Total	Pct
Polycladida sp. A					2													2	0.03	99.02
Hemichordata sp.				1				1										2	0.03	99.05
Nemertea sp. D													1	1				2	0.03	99.08
Notopygos crinita													1					1	0.02	99.10
Amphinomidae sp.					1													1	0.02	99.12
Cauleriella sp. A																	1	1	0.02	99.14
Cauleriella sp. B									1									1	0.02	99.16
Goniadidae sp.												1						1	0.02	99.18
Polynoidae sp. A				1														1	0.02	99.20
Polynoidae sp. B																	1	1	0.02	99.22
Scolelepis squamata		1																1	0.02	99.24
Eusyllis sp. C				1														1	0.02	99.26
Terebellidae sp. A																	1	1	0.02	99.28
Chione cancellata												1						1	0.02	99.30
Tellina listeri					1													1	0.02	99.32
Tellina sp. B							1											1	0.02	99.34
Ervilia subcancellata									1									1	0.02	99.36
Trachycardium muricatum				1														1	0.02	99.38
Crepidula sp.																	1	1	0.02	99.40

Species	Stations:	June 1977 1	2	3	4	Sept. 1977 1	2	3	4	Dec. 1977 1	2	3	4	Mar. 1978 1	2	3	4	Total	Pct. Total	Cumulative Pct.
Bivalvia sp. A															1			1	0.02	99.42
Bivalvia sp. B			1															1	0.02	99.44
Bivalvia sp. D				1														1	0.02	99.46
Macromphalina sp.												1						1	0.02	99.48
Acmaea sp.												1						1	0.02	99.50
Dentalium sp. B								1										1	0.02	99.52
Dentalium sp. C												1						1	0.02	99.54
Olivella nivea								1										1	0.02	99.56
Conus floridanus												1						1	0.02	99.58
Morula didyma									1									1	0.02	99.60
Penaeus sp.											1							1	0.02	99.62
Penaedae sp.						1												1	0.02	99.64
Majiidae sp. B					1													1	0.02	99.66
Portunis sp.							1											1	0.02	99.68
Paguridae sp.								1										1	0.02	99.70
Ostracoda sp					1													1	0.02	99.72
Tanaidacea sp. A												1						1	0.02	99.74
Tanaidacea sp. B									1									1	0.02	99.76
Tanaidacea sp. C						1												1	0.02	99.78
Tanaidacea sp. D					1													1	0.02	99.80

Species	June 1977 Stations: 1	2	3	4	Sept. 1977 1	2	3	4	Dec. 1977 1	2	3	4	Mar. 1978 1	2	3	4	Total	Pct. Total	Cumulative Pct.
Metaprotella hummelineri			1														1	0.02	99.82
Cilicaea caudata						1											1	0.02	99.84
Anthuridae sp.						1											1	0.02	99.86
Colanthura sp.			1														1	0.02	99.88
Leptognathia sp			1														1	0.02	99.90
Palaemonidae sp.	1																1	0.02	99.92
Synalpheus sp.		1															1	0.02	99.94
Larval crustacean												1					1	0.02	99.96
Emerita talpoida										1							1	0.02	99.98
Hemipteronotus sp.						1											1	0.02	100.00
Mellita quinquesperforata				1													1	0.02	100.02
Station Totals																			
Number of Species	44	38	80	65	63	42	86	60	30	26	98	58	39	41	67	66			
Number of Individuals	216	187	539	1514	404	126	631	236	322	305	517	204	103	151	283	195			
Seasonal Totals																			
Number of Species	133				133				125				108						
Number of Individuals	2456				1397				1348				732						
Grand Totals																			
Number of Species	224																		
Number of Individuals	5933																		

APPENDIX B

NUMBER OF INDIVIDUALS COLLECTED AT ALL STATIONS BY FAUNAL GROUPS

Phylum Annelida
Class Polychaeta

	Station 1	Station 2	Station 3	Station 4	Total
Lumbrinereis tenuis	74	74	125	71	344
Aricidea jeffreysi	30	30	38	29	127
Armandia agilis	25	39	11	14	89
Axiothella mucosa	32	10	33	10	85
Prionospio fallax	10	9	54	10	83
Polydora socialis		1	72	4	77
Aricidea sp.	16	11	32	15	74
Neonotomastus glabrus	6	10	36	13	70
Lumbrinereis acuta	15	14	24	12	65
Aedicira sp.	4	6	8	31	49
Drilonereis sp. A	8	14	24	1	47
Aonides sp.	12	1	26	6	45
Syllis (Langerhansia) sp.		1	21	23	45
Drilonereis sp. C	1		27	14	42
Paranois sp.	5	24	5	5	39
Exogone dispar	4		20	5	29
Chone sp.		2	17	10	29
Drilonereis sp. B		2	12	13	27
Chaetozone sp.			14	12	26
Eusyllis sp. A	6	3	13	4	26
Hesionidae sp.	5		10	9	24
Sigalion sp.	2	5	9	8	24
Scoloplos rubra	4	2	14	3	23
Minuspio sp.	1	16	3	2	22
Prionospio cristata	3	1	6	11	21
Glycera sp.	2	6	6	3	17
Onuphis eremita		1	10	6	17
Onuphis pallidula		2	11	4	17
Poecilochaetus sp.	1		8	8	17
Thalenessa sp.	5		9	3	17
Phyllodoce mucosa	1		9	6	16
Branchyosycis sp.	12			3	15
Onuphis sp.			12	3	15
Schistomeringos rudolphi		1	5	8	14
Capitellidae sp. B	4	4	2	1	11
Polynoidae sp. C	7		4		11
Apoprionospio dayi	2	5	2	2	11
Malacoceros glutaeus	4	1	2	4	11
Euphrosine sp.	1		8	1	10
Magelona sp.			6	4	10
Americonuphus sp.	2		3	4	9
Loimia medusa	1		7	1	9
Nephtys picta	2		2	4	8
Nereidae sp. A			5	1	8
Commensodorum commensalis	1		6	1	8

	Station 1	Station 2	Station 3	Station 4	Total
Sabellidae sp. B	1	1	6		8
Armandia maculata				7	7
Pholoe sp.	3	1	1	2	7
Prionospio sp.				7	7
Paraprionospio pinnata	2	1	4		7
Spio pettiboneae		3	2	2	7
Pseudocirratulus kingstonensis			4	2	6
Lumbrineridae sp. A		1	4	1	6
Minuspio cirrifera	1	1	3	1	6
Eusyllis sp. B		1	4	1	6
Phyllodoce (Gentyllis) sp.		1	3	1	5
Syllis (Typosyllis) sp.			5		5
Exogone sp.		1	4		5
Notomastus sp.			4		4
Phyllodocidae sp. C			4		4
Syllidae sp.			1	3	4
Capitellidae sp. A			1	2	3
Lumbrineridae sp. B	1			2	3
Nereidae sp. B		1	1	1	3
Orbinia sp.		1	1	1	3
Sabellidae sp. A			3		3
Malacoceros sp. B			3		3
Polychaeta sp.			3		3
Dasybranchus sp.			2		2
Capitella sp.	1		1		2
Magelona pettiboneae		1	1		2
Phyllodocidae sp. A			2		2
Phyllodocidae sp. B			2		2
Malacoceros sp. A			2		2
Dispio uncinata			2		2
Parapionosyllis sp.	1			1	2
Notopygos crinita				1	1
Amphinomidae sp.				1	1
Cauleriella sp. A			1		1
Cauleriella sp. B				1	1
Goniadidae sp.			1		1
Polynoidae sp. A			1		1
Polynoidae sp. B				1	1
Scolelepis squamata	1				1
Eusyllis sp. C			1		1
Terebellidae sp.				1	1

	Station 1	2	3	4	Total
Class Oligochaeta					
Oligochaeta sp. A			61	2	63
Oligochaeta sp. B			13	2	15
Oligochaeta sp. C	1		1	1	3
Phylum Mollusca					
Class Bivlavia					
Ervilia nitens	231	196	45	930	1402
Ervilia concentrica	53	8	150	282	493
Transennella stimpsoni	97	53	178	98	426
Pleuromeris tridentata	82	6	103	29	220
Tellina gouldii	14	9	4	7	34
Tellina versicolor	6		13	9	28
Crasinella lunulata	11	1	4		16
Juvenile bivalves			14		14
Crenella sp.			7	6	13
Varicorbula operculata			7	5	12
Astenothaerus hemphilli			8	2	10
Strigilla mirabilis	5	3	1	1	10
Veneridae sp.	1	4	4		9
Lima sp.			2	6	6
Lucina sp.			6		6
Pteromeris perplana			6		6
Cooperella atlantica		1	5		6
Chione latirata			1	4	5
Tellina sp. A	3		2		5
Bivalvia sp. C		3	1		4
Lucina radians		2			2
Crasinella sp.				2	2
Laevicardium laevigatum		1	1		2
Pandora bushiana			2		2
Semele ballastriata			1	1	2
Chione cancellata			1		1
Tellina listeri				1	1
Tellina sp. B		1			1
Ervilia subcancellata				1	1
Trachycardium muricatum			1		1
Bivalvia sp. A		1			1
Bivalvia sp. B	1				1
Bivalvia sp. D			1		1
Class Gastropoda					
Zebina browniana	1	1	11	3	16
Sigatica carolinensis	4		2	3	9
Polinices lacteus			5	2	7

	Station 1	2	3	4	Total
Tivela floridana			3	3	6
Atys caribaea	3		3		6
Marginella eburneola		1	3	2	6
Natica canrena	1	1		3	5
Acteocina candei				5	5
Mitrella ocellata	1	3	1		5
Olivela floralia	2		2		4
Tricolia thalassicola	1		3		4
Pisania tincta			4		4
Marginella lavalleeana	2			1	3
Odostomia sp.			1	1	2
Natica sp.				2	2
Mitrella raveneli			2		2
Crepidula sp.				1	1
Macromphalina sp.			1		1
Acmaea sp.			1		1
Olivella nivea			1		1
Conus floridanus			1		1
Morula didyma				1	1
Class Scaphopoda					
Caecum imbricatum	10	8	61	27	106
Polyschides quadridentatus			8	3	11
Coccodentalium cardum	1		6	1	8
Cadulus sp.	2	2	2	1	7
Dentalium semistriolatum	1			2	3
Dentalium floridense			1	1	2
Dentalium sp. A		1		1	2
Dentalium sp. B			1		1
Dentalium sp. C			1		1
Class Polyplacophora					
Lepidopleurus pergranatus			3		3
Phylum Arthropoda					
Class Crustacea					
larval crustacean				1	1
Subclass Ostracoda					
Ostracoda sp. B			2		2
Ostracoda sp. A				1	1
Subclass Malacostraca					
Superorder peracarida					
Order Mysidacea					

	Station 1	2	3	4	Total
Mysidacea sp. A	9	4	2		15
Mysidacea sp. B	4	1		1	6
Order Cumacea					
Bathycuma longicaudata	6	3	5	3	17
Cyclapsis varians		1	1	3	5
Cumacea sp. A				2	2
Order Tanaidacea					
Apseudes sp.	11	1	126	61	199
Kalliapseudes sp.			21	22	43
Tanaidacea sp. A			1		1
Tanaidacea sp. B				1	1
Tanaidacea sp. C	1				1
Tanaidacea sp. D				1	1
Order Isopoda					
Xenanthura brevitelson	5	2	4	3	14
Serolis mgrayi	4	3	1		8
Serolis sp.	1		2	1	4
Cilicaea caudata		1			1
Anthuridae sp.		1			1
Colanthura sp.			1		1
Leptognathia sp.			1		1
Order Amphipoda					
Trichophoxus floridanus	44	64	5	4	117
Platyischnopus sp.	39	35	5	5	84
Phtisica marina	5	3	7	23	38
Gammaridea sp. A	9	7	8	6	30
Parahaustorius sp. A	11	6	1		18
Synchelidium americanum	1	3	3		7
Parahaustorius sp. B	4	1			5
Luconacia incerta	1		2	1	4
Gammarus sp.			3	1	4
Ampelisca sp.	1		1	1	3
Paracaprella pusilla				2	2
Caprellidae sp. A				2	2
Metaprotella hummelineri			1		1
Superorder Eucarida					
Order Decapoda					

	Station 1	2	3	4	Total
Processa sp.	7		4	1	14
Portunis depressifrons	1	5		1	7
Penaeidae sp. A	2		1	2	5
Alpheidae sp	5				5
Thalassinoidea sp.			4		4
Pinnixa retinens			3		3
Cycloes barrdii		1	2		3
Majidae sp.		1		1	2
Batrachonotus fragosus			2		2
Penaeus sp.		1			1
Penaeidae sp.	1				1
Majidae sp. B				1	1
Portunis sp.		1			1
Paguridae sp			1		1
Palaemonidae sp.	1				1
Synalpheus sp.		1			1
Emerita talpoida			1		1
Subphylum Chelicerata					
Class Pyconogonida					
Pallenopsis schmitti			3		3
Pycnogonida sp.			3		3
Phylum Rhynchocoela					
Nemertea sp. A	7		14	4	25
Nemertea sp. B			2	4	6
Nemertea sp. C			1	4	5
Nemertea sp. D			1	2	3
Nemertea sp. E	1			1	2
Phylum Platyhelminthes					
Class Turbellaria					
Order Polycladida					
Polycladida sp. B			3		3
Polycladida sp. A				2	2
Phylum Sipuncula					
Aspidosiphon albus	4	1	83	71	159
Sipuncula sp. A		3	1		4
Sipuncula sp. B	1		1	1	3

	Station				
	1	2	3	4	Total
Phylum Echiura					
Echiura sp.		2			2
Phylum Enchinodermata Class Ophiuroidea					
Ophiuroidea sp.			3		3
Class Echinoidea					
Mellita quinquesperforata				1	1
Phylum Hemichordata					
Hemichordata sp.			2		2
Phylum Chordata Subphylum Cephalochordata					
Branchiostoma (*caribaeum*)	5		14	5	24
Subphylum Vertebrata Class Osteichthyes					
Gillelus greyae	1	1		1	3
Hemipteronotus sp.		1			1

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